

BWI Hilton Hotel



Thomas Sabol

The Pennsylvania State University

Architectural Engineering

Structural Emphasis

Advisor: Dr. Ali M. Memari

Senior Thesis Presentations: Spring 2007



Presentation Overview

- Introduction
- Existing Structure
- Problem Statement/Proposal
- Structural Redesign:
 - Girder-Slab for Typical Floors
 - Composite Beam for Ground – 3rd Floor
 - Braced Frames
 - Footings
- Cost & Schedule
- LEED Hotel Research
- Conclusions

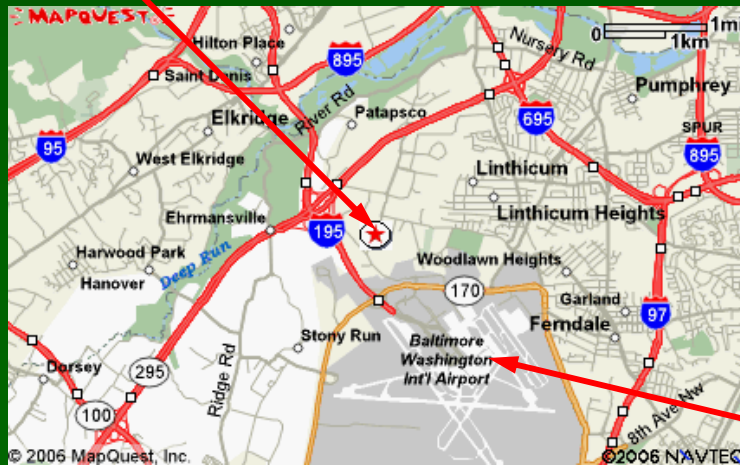


Introduction

- 131' Hotel -11-Stories & Penthouse
- 203,300 s.f.
- 280 Guest Rooms
- 80-Car Parking Below Ground
- Aqua Restaurant



Hotel

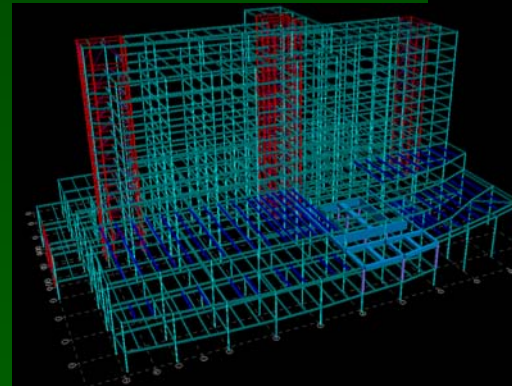
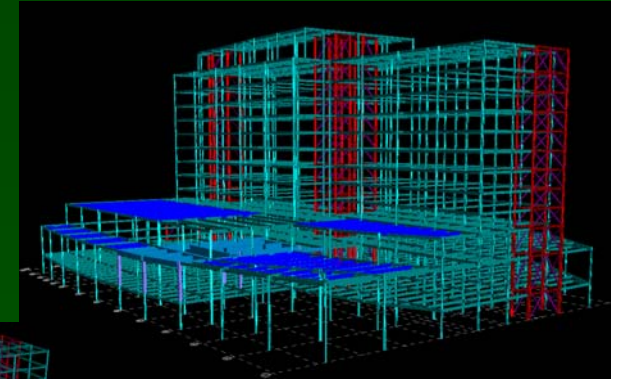


Located: Linthicum Heights, Maryland
0.5 miles from BWI Airport

Height Restriction: $\approx 290'$ from datum

Airport

Introduction



“Adjacent Structure”

-Framed in Structural Steel

Includes:

-Main Entrance

-8,300 s.f. Double Heighted-Ballroom

- Pool Area (Epoxy Reinf.) Concrete



BWI Hilton Hotel

Project Team

Owner: **Buccini-Pollin**

Architect: **Brennan Beer Gorman Monk**

Structural Engineer: **Holbert Apple Associates**

MEP Engineer: **R G Vander Weil Engineers**

Geotech Engineer: **ECS, Ltd**

General Contractor: **HITT Contracting Inc.**



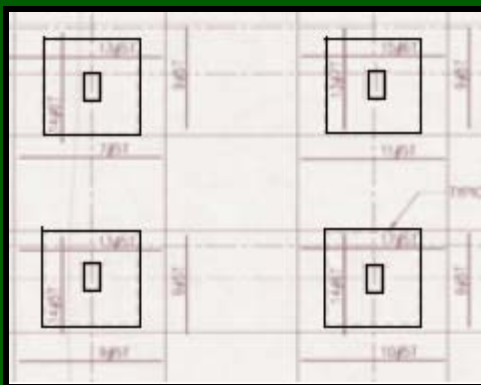
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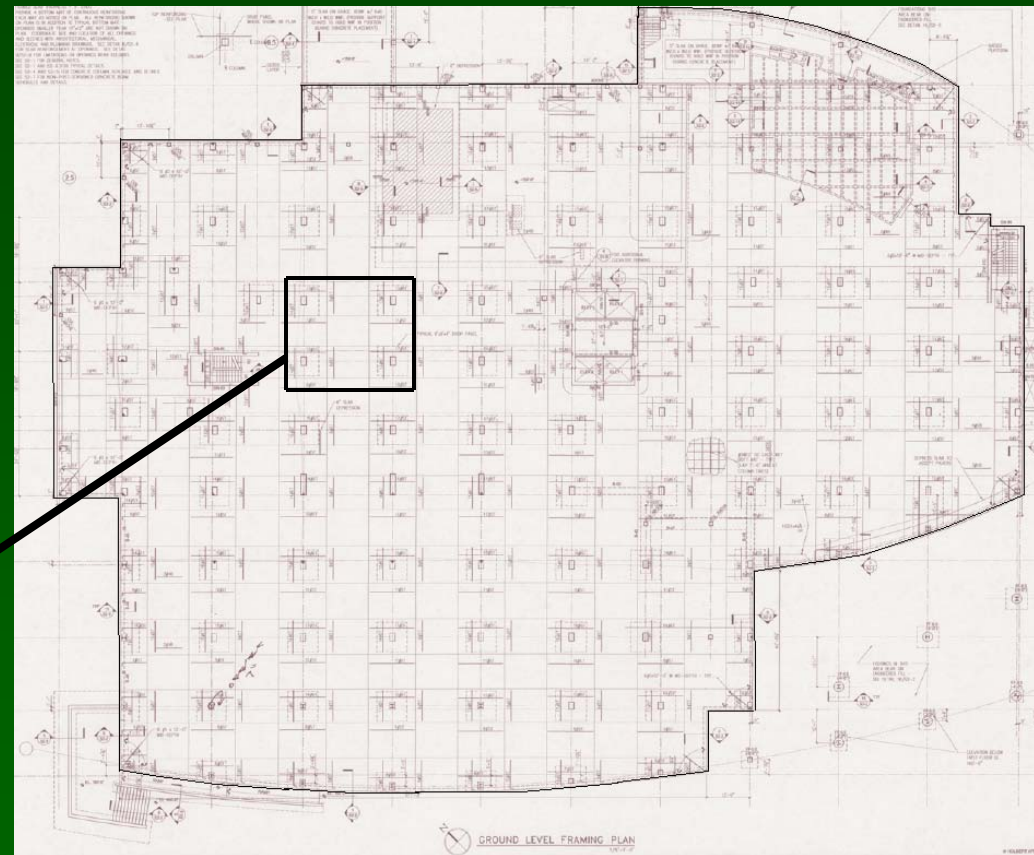


Existing Structure – Gravity System

- 9" Flat Slab
- 9'x9'x4" Drop Panel
- Mild Reinforced
- $f'_c = 4000$ psi
- Bay size typical 27'x20'



Columns $f'_c = 5600$ psi

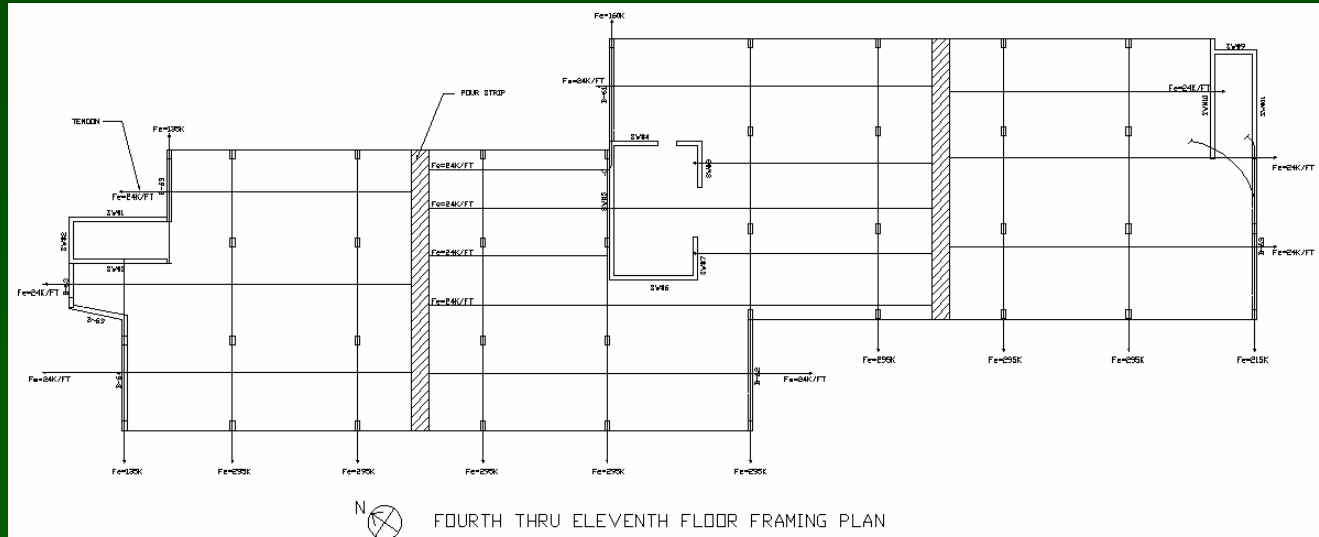


Ground Floor Framing



Existing Structure – Gravity System

- 7-1/2" Flat Plate
- Post Tension
- $f'c = 4000$ psi
- $Fe = 295$ Kips in E-W
- $Fe = 24$ Kips/ft in N-S



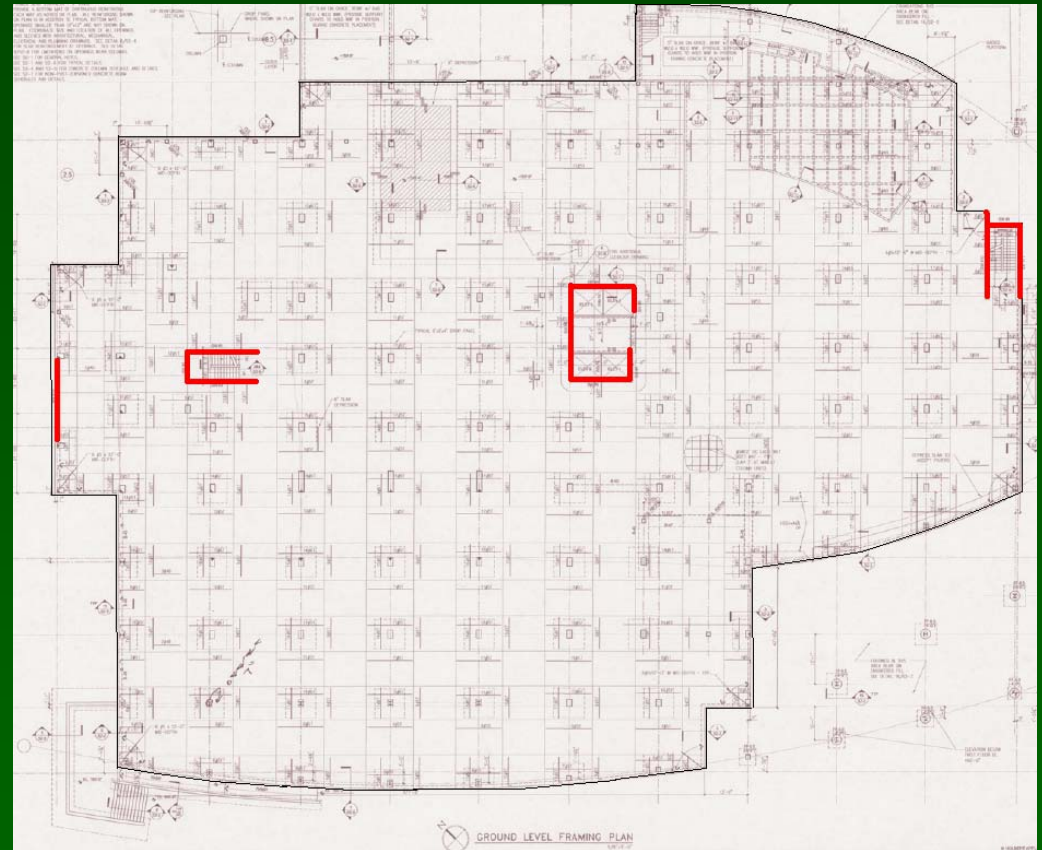
Typical Framing Plan 4-11

Columns $f'c = 4000$ psi



Existing Structure – Lateral System

- 12 Shear Walls
 - 3 around each stair Tower
 - 5 around elevator core
 - 1 extends to 2nd Floor
- 12" Thick
- $f'_c = 4000$ psi



Shear Wall Locations



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Problem Statement

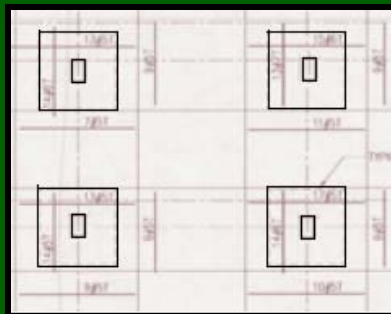
Height Restriction: $\approx 290'$ from datum (Federal Aviation Administration)

Air Traffic



Disruption of Architecture

Same Bay Layout



Bottom of Flat Plate

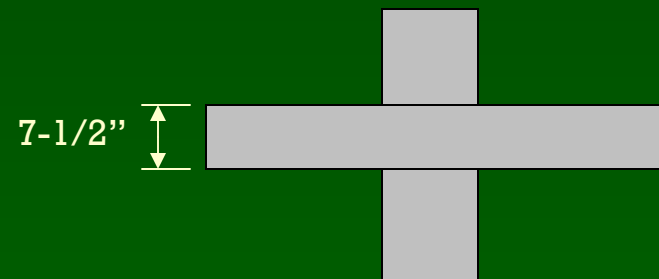




Proposal Goals

Preserve Architecture

Comparable Steel Structure



Post Tension Flat-Plate

Hotel Benefit

- Redesigned Structure
- Faster Erection

\$\$\$



Presentation Overview

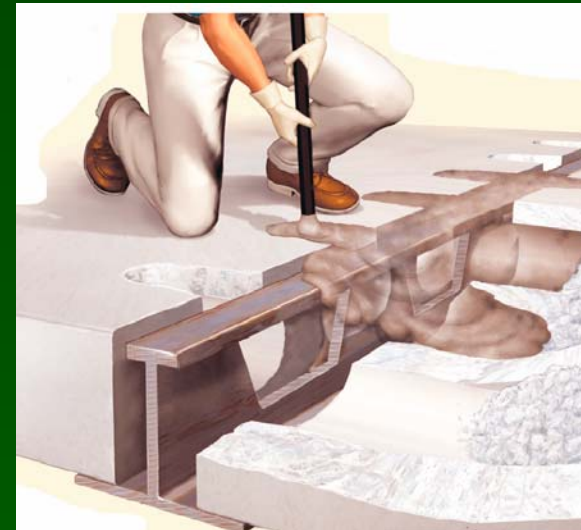
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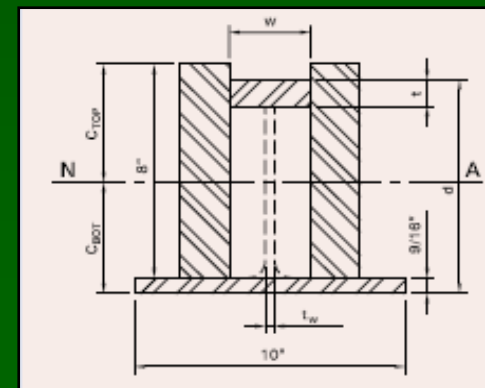
BWI Hilton Hotel

Girder-Slab System

Composite Action through Grouting



Transformed Section





Girder-Slab System for Typical Floors 4-11

Designs Goals

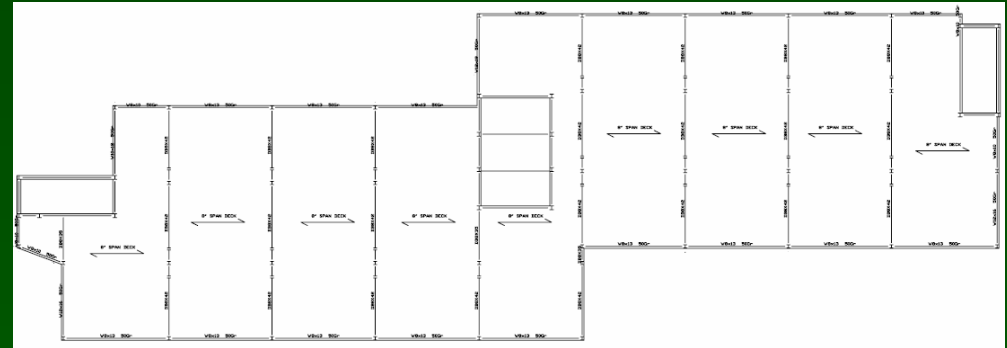
- Comparable Thickness of PT
(7-1/2")

Design Parameters

- Strength → Live Load: 40 psf
- Deflection

Design Method

- ASD, Girder-Slab Design Guide
- Manual Calculations

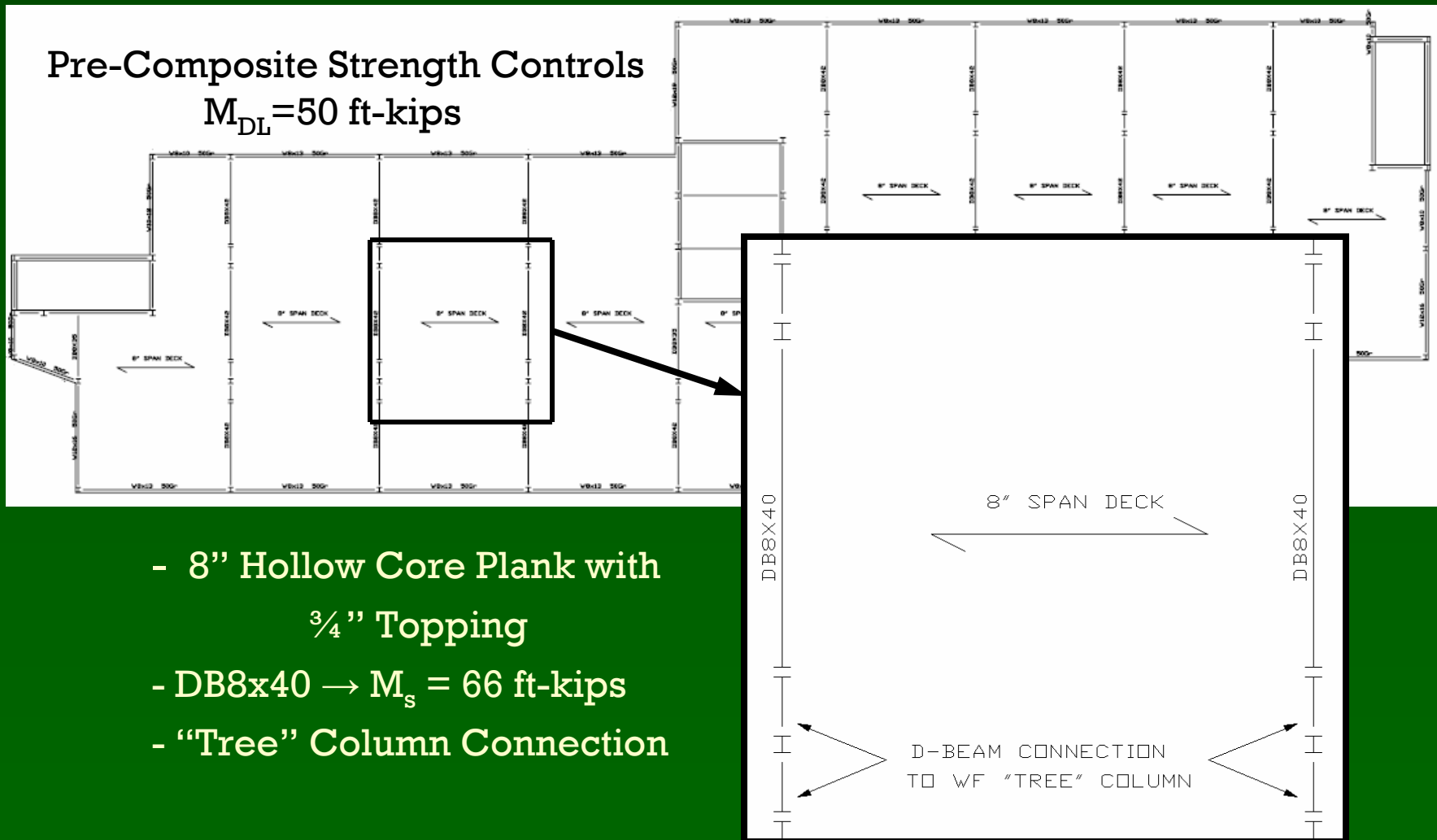


Floors 4-11



Girder-Slab System for Typical Floors 4-11

Pre-Composite Strength Controls
 $M_{DL} = 50$ ft-kips

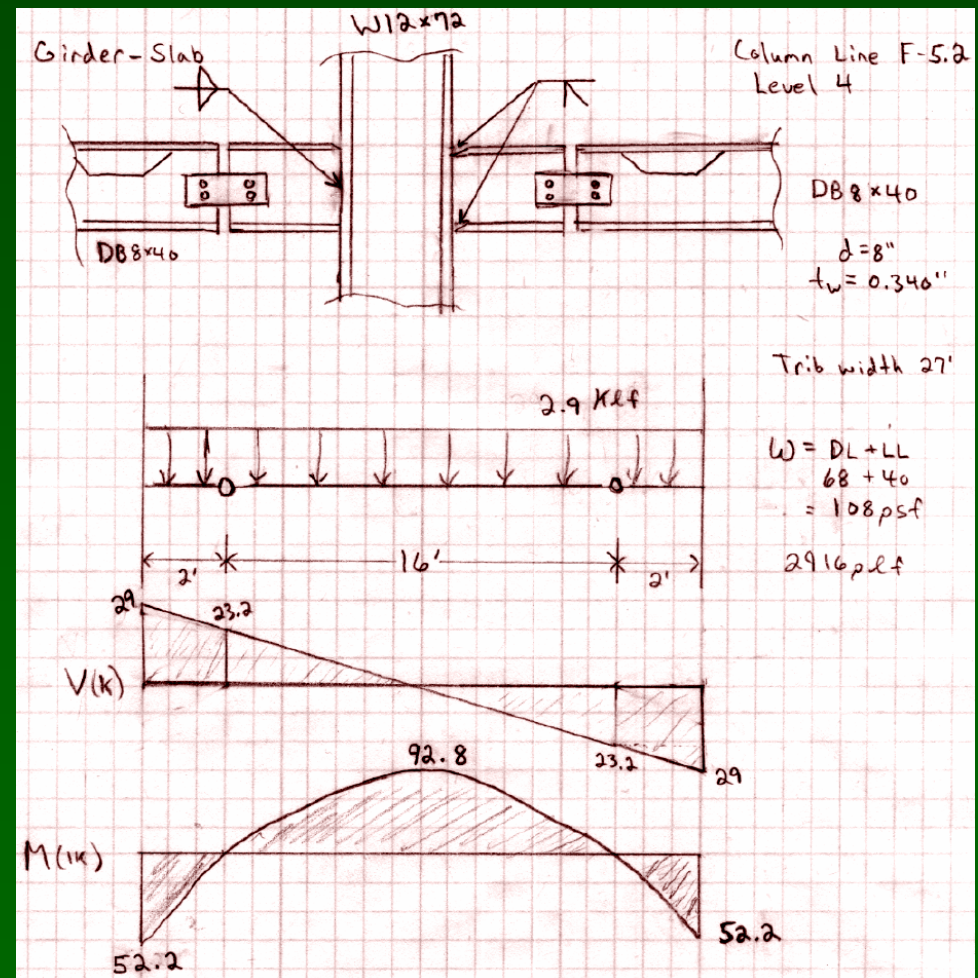
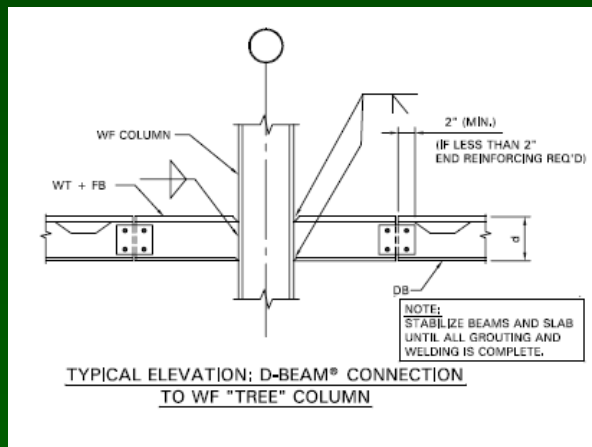


- 8" Hollow Core Plank with $\frac{3}{4}$ " Topping
- DB8x40 $\rightarrow M_s = 66$ ft-kips
- "Tree" Column Connection



Girder-Slab System for Typical Floors 4-11

DB Connection to WF "Tree" Column



- 23.2 Kips Shear at Hinge
- 3/8" Plate w/ 2 – 7/8" ϕ A325N bolts
- "Tree" - WT8x22.5
- Fillet both sides & Bevel Weld
- 52.2 ft-Kips at Column face



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Composite Beam and Slab for Floors G-3

Designs Goals

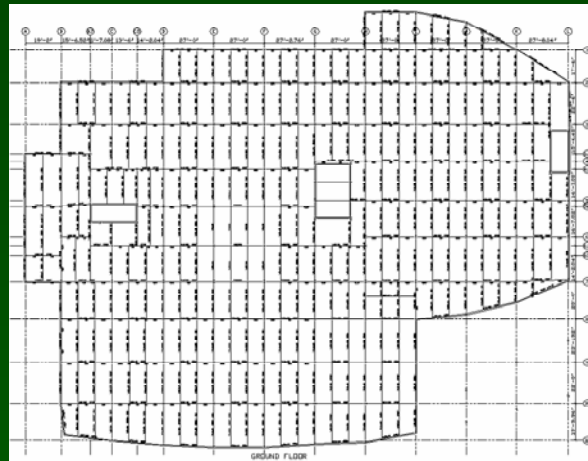
- Comparable Structure

Design Parameters

- Strength → LL: 100 psf
- Deflection
- Vibration

Design Method

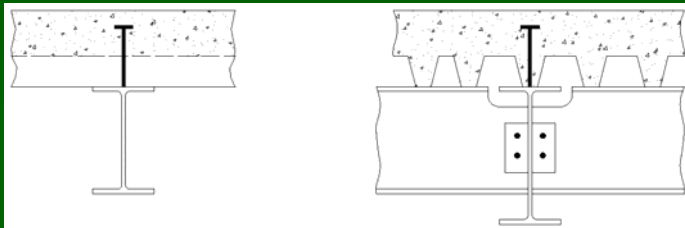
- ASD
- RAM Structural System



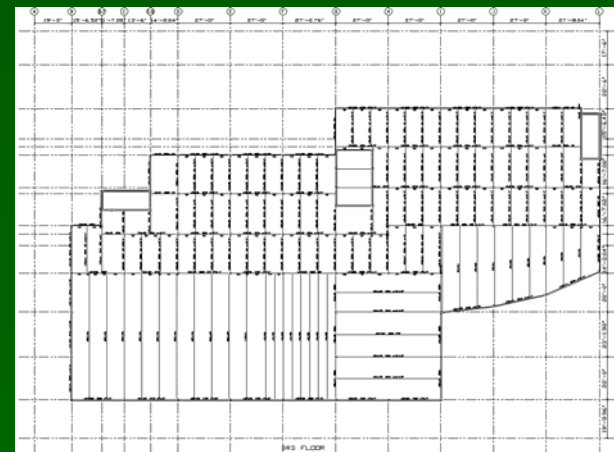
Ground Floor



2nd Floor



2" LOK-Floor Deck
3" Concrete



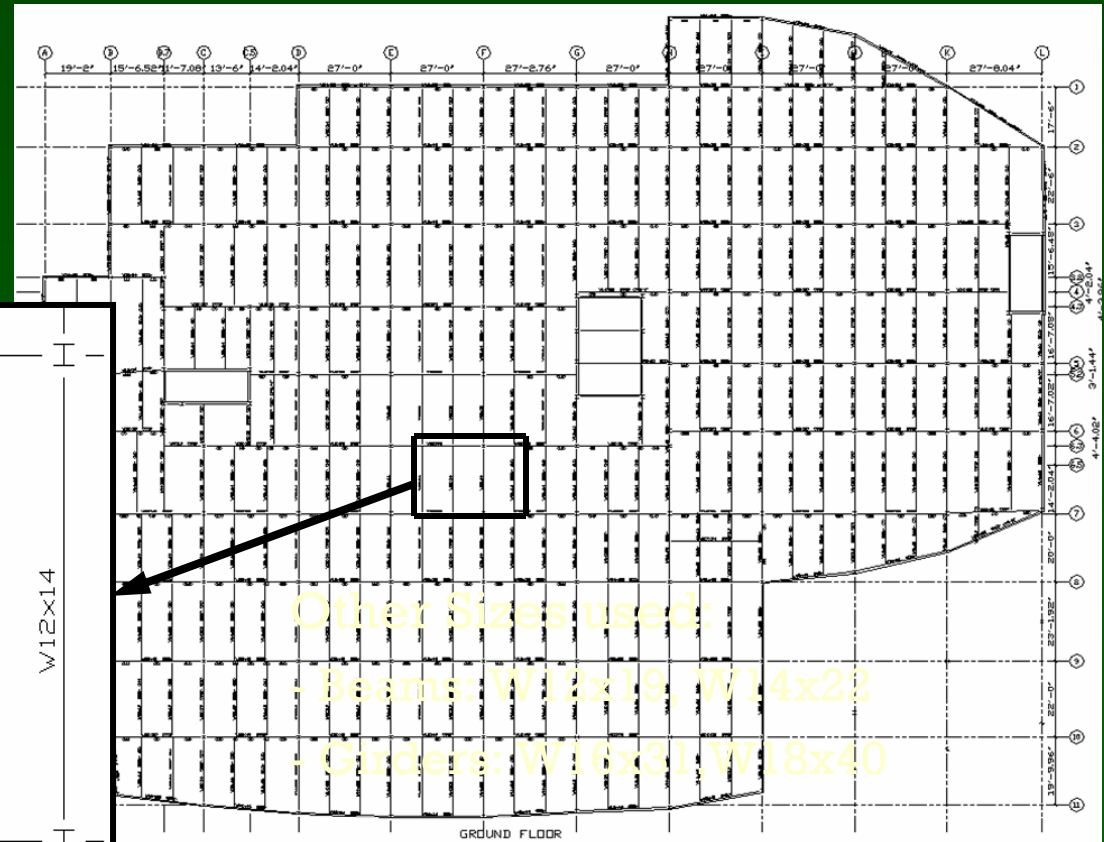
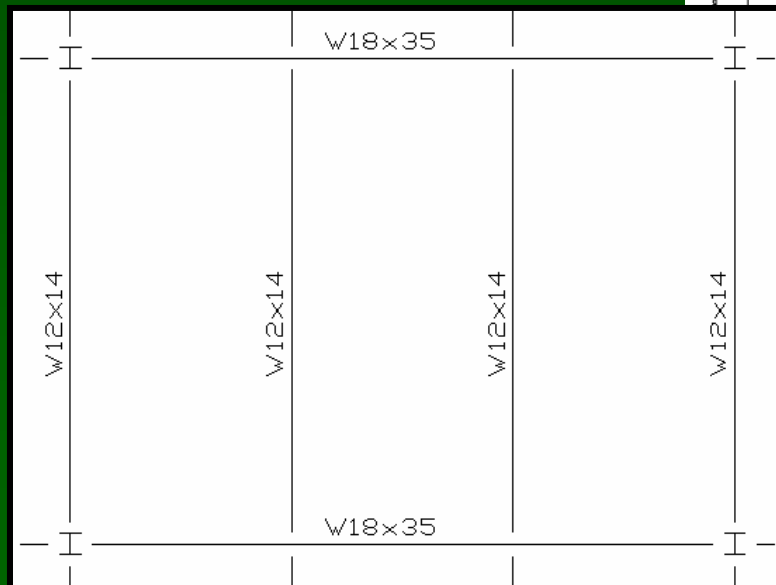
3rd Floor



Composite Beam and Slab for Floors G-3

Deflection Controlled Design

- $L/240$ for Total Loading
- $I_{LB} \geq 171 \text{ in}^4$ for Beams
- $I_{LB} \geq 853 \text{ in}^4$ for Girders



Other Sizes used:

- Beams: W12x19, W14x22

- Girders: W16x31, W18x40



Walking Vibrations Checked for Office Area

Full height Partitions

$$\beta = 0.05$$

Natural Frequencies

- Beam Mode 10.2 Hz
- Girder Mode 7.28 Hz
- Combined Mode 5.93 Hz

$$\frac{a_p}{g} = \frac{P_0 \exp(-0.35f_n)}{\beta W}$$

$$a_p/g = 0.31\%g$$

Recommended Limit
for Offices: $0.5\%g \rightarrow \text{OK}$





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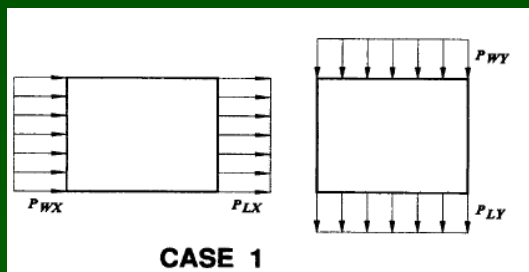


Lateral Loads Obtained from ASCE7-05

Wind Loads

Basic Wind Speed 90 mph

Case 1 Loading Controlled



Base Shears

N-S 191 Kips

E-W 543 Kips

Equivalent Lateral Force Method

Seismic Design Category: B

$S_{DS} = 0.160$ $S_{D1} = 0.085$

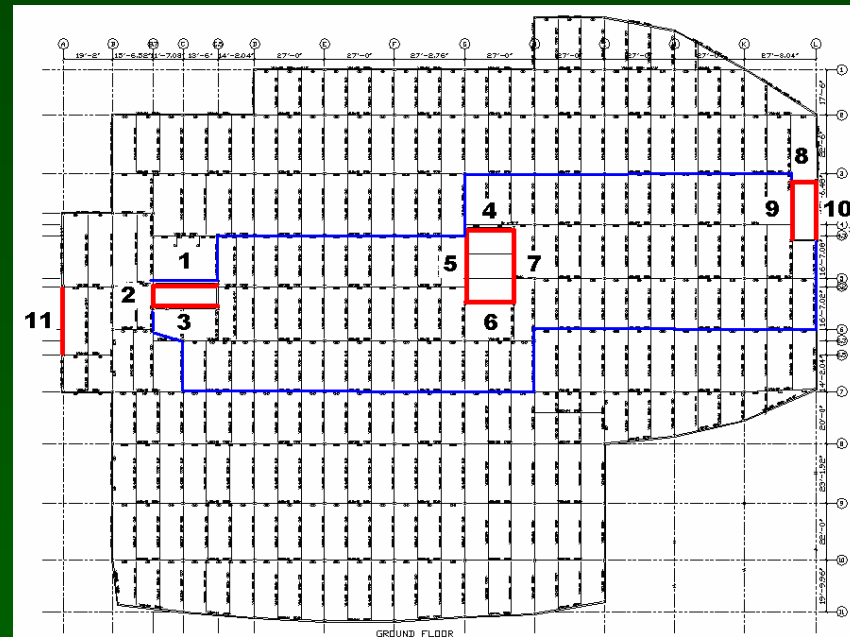
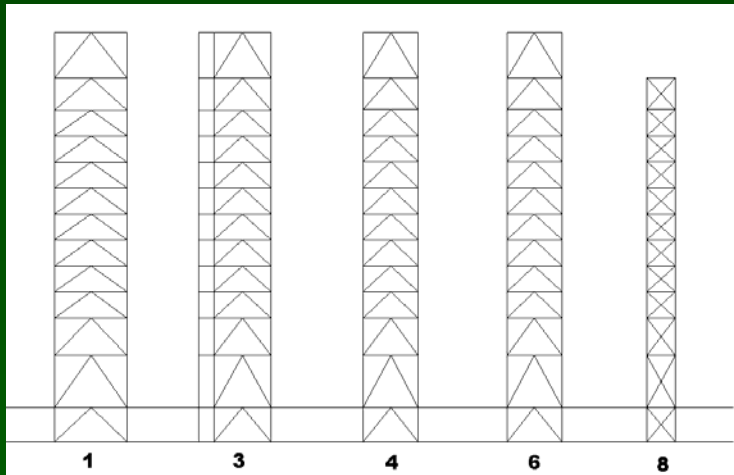
R = 3.25 (Ord. Steel Conc. Braced Frames)

Base Shear 469 Kips





Braced Frames Resist Lateral Loads



Chevrons & Cross Braces

HSS & Double Angles

Iterative Process to Design Braced Frames



Braced Frame #5

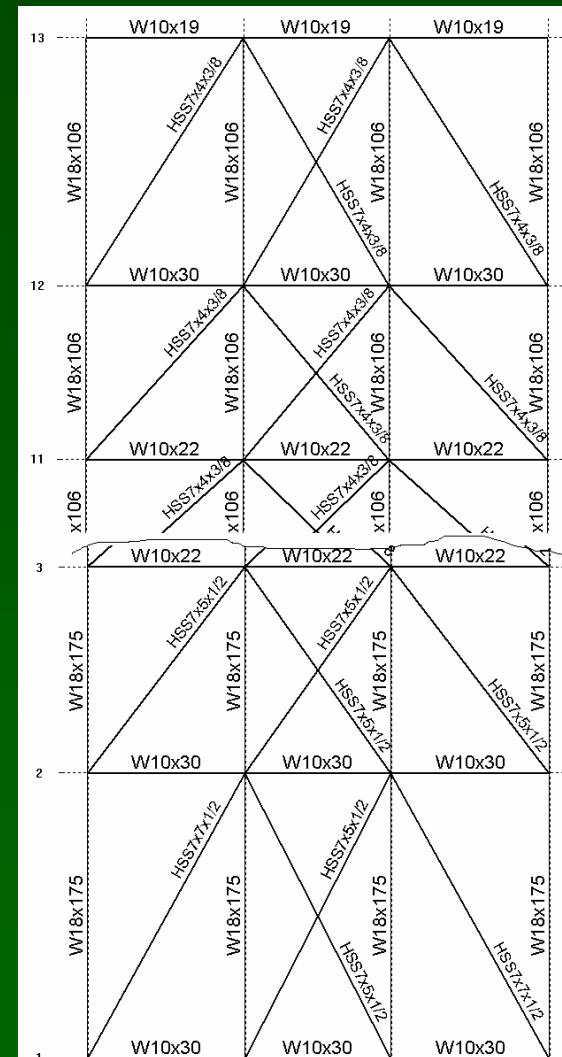
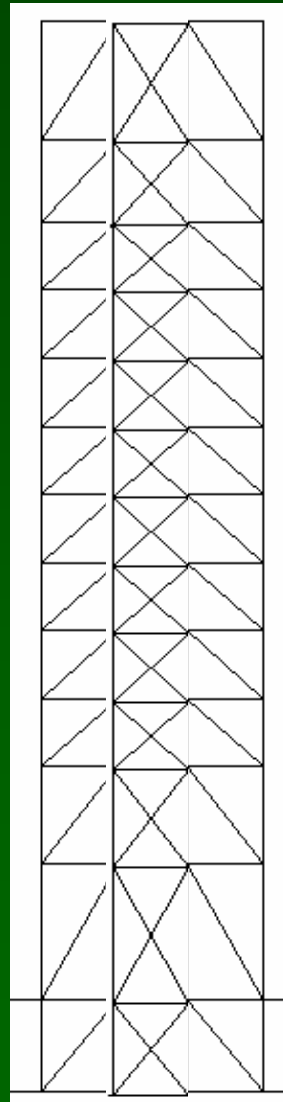
Design Controlled by Displacement of $H/400$

Cross Braces Increased Stiffness by a Factor ≈ 3

Column sizes were Increased

Brace sizes were Increased

Members Checked for ASD Load Combinations





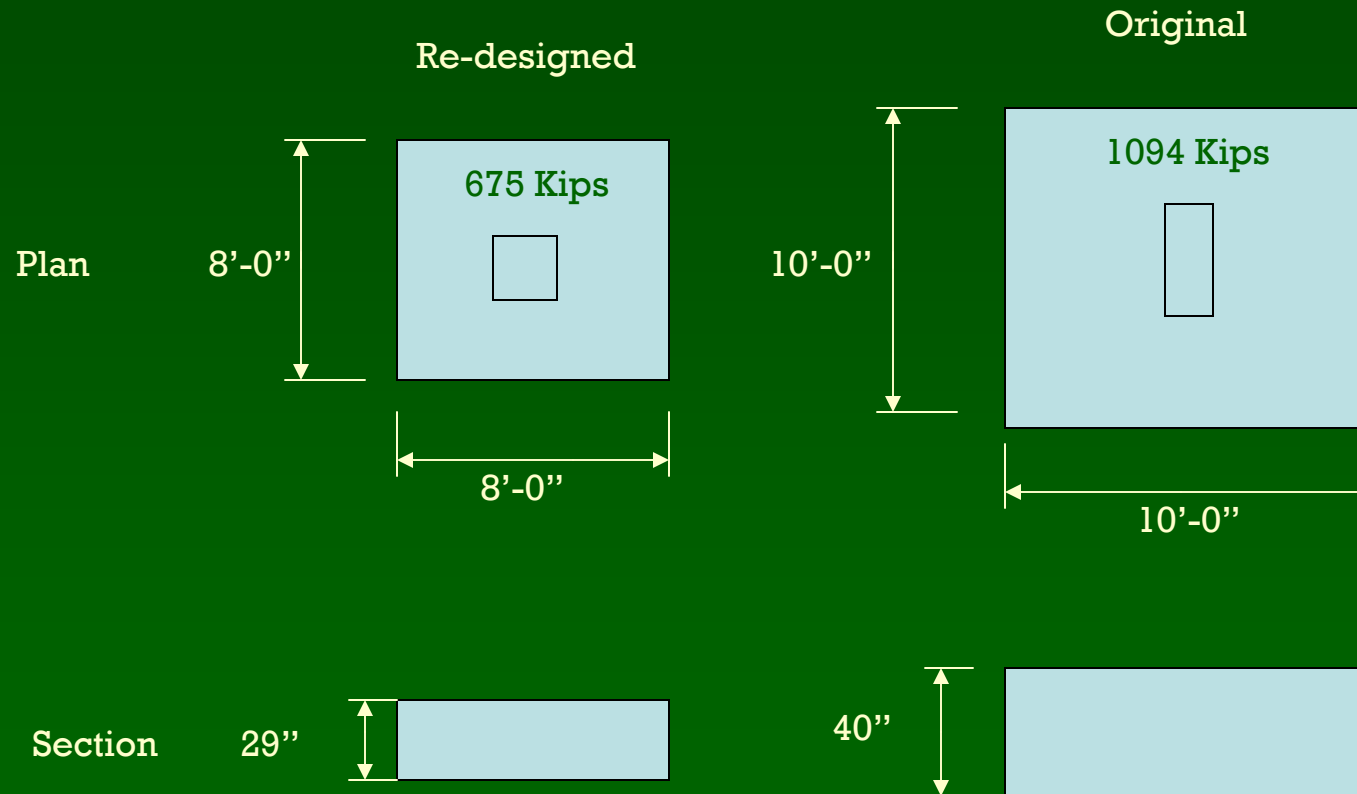
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Footing Sizes Decrease for Steel Structure

Footing at Column Line F-5.2



Decrease in Volume by 53%



Footings Sizes Decrease for Steel Structure

Two other footings were resized:

Concrete Volumes Decreased by 50% and 63%

Existing Footing Volume: 390 yd³

50% of Existing: 195 yd³

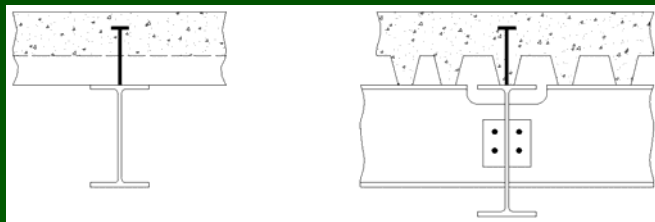
R.S. Means Cost per Footing: \$370/yd³

Savings of \$72,150.00



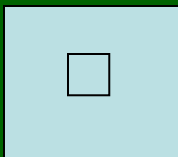
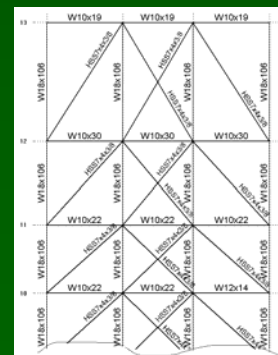
Structural Depth Recap

Girder-Slab system for Typical floors 4-11



Composite Beam for floors ground-3rd

Braced Frames resist lateral loads



50% Reduction in Footings.



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Cost Comparison of Systems

System	Component	S.F. Cost	Total Cost Including O&P
Steel	Composite Beam	\$22.55	\$5,192,391.73
	Girder Slab	\$17.11	
	Braced Frames	\$3.89	
CIP Concrete	Slab w/ Drop Panels	\$21.23	\$5,126,712.35
	Post tension	\$21.52	
	Shear Walls	\$1.80	



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Schedule Reduced from Girder-Slab System



Erection of Concrete Structure

189 Calendar days



Erection of Steel Structure

144 Calendar days

Schedule Reduced by 45 Days!



BWI Hilton Hotel

Schedule Impacts on Hotel

Average Occupancy: 180 rooms per Night

Average Hotel Cost: \$211.50 per Room

Hotel Opens 45 days Earlier



Hotel would Generate a Revenue of:

\$1,713,150.00



Summary of Cost Analysis

	Cost	Savings
CIP Concrete	5,126,712.35	
Steel	5,192,391.73	
Difference	-\$65,679.38	
Reduced Footings		\$72,150.00
Generated Revenue from earlier opening date		\$1,713,150.00
Savings from Steel System		\$1,719,620.62

Hotel would Save/Generate:

\$1,719,620.00!!



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LEED Certified Hotel Research

1st LEED Certified Hilton Hotel

LEED strategies:

- Buying locally
- Dimmable Fluorescents
- CO₂ monitoring
- Recycle Construction Waste



Hilton Vancouver Washington

30 People Surveyed
Consumers' Preference





BWI Hilton Hotel

LEED Certified Hotel Research

What does the Consumer want?

- Willing to Pay Slightly more
- Desirable Location
- Information



“Doing Our Part to be Environmentally Conscious”

This hotel received a LEED certification for sustainable practices. To learn more about these accomplishments inquire at the front desk.



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Conclusions & Recommendation

Use Redesigned Steel System

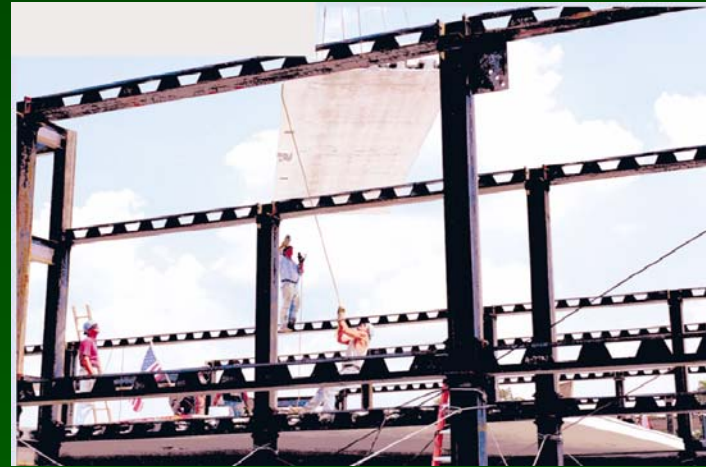
Why?

Girder-Slab System:

- Cuts down Schedule
- Comparable to PT floor thickness (1-1/4" thicker)

Steel System:

- Reduces Footing Sizes
- Overall Savings/Earnings of **\$1,719,620.00**





BWI Hilton Hotel

Acknowledgments

David Holbert, Holbert Apple & Associates: Providing my
Building & Drawings

AE Faculty: Guidance & Patience

THANK YOU!!

Industry Professionals: Providing Help & Information

5th AE students: Endless Entertainment & Help

Family & Friends: Love and Support throughout the years



BWI Hilton Hotel

Questions?

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